

Improving Ecological Risk Assessments of Surface and Groundwater Exposures: *Realistic Monitoring Approaches that Reduce Uncertainty in an Efficient Manner*

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Critical Weaknesses

- Establishing stressor causality
- Spatial and temporal variability
- Measuring exposure accurately
- Extrapolating effects
- Sampling/testing artifacts
- Appropriate references

Approach Comparisons

- Sediment Quality Guidelines (chemical specific)
- Lab toxicity (whole sediment assays)
- Habitat quality (QHEI)
- Benthic macroinvertebrate indices
- Indigenous species tissue residues
- *In situ* toxicity and bioaccumulation (multi-compartment)
- Toxicity identification evaluation (TIE) (lab & *in situ*)
- Food web modeling

Sites Evaluated (1998-2000)

- Clark Fork River, MT (Metals)
- Little Scioto River, OH (PAHs)
- Dicks Creek, OH (PCBs)
- Wolf Creek, OH (Varied)
- Mad River, OH (Varied)
- Lower Housatonic R., MA (PCBs)
- Sebasticook R., ME (Chlorobenzenes)

Tier 1: Stress Demonstration

Site Reconnaissance



Sample Design Issues

- Bioaccumulation - *tissue design*
- PAHs - *phototox testing*
- GW/SW interactions - *piezometer design*

Exposure

reference sites vs. stressor gradient

Compartment

- Water column
- Interface (sed/water)
- Surficial sediment
- Pore water

Event

- Low flow
- High flow
- Seasonal
- Diel

Period

- 1- 30 d

Physicochemical
Profiles

Effects

Species

- *H. azteca*
- *D. magna*
- *C. dubia*
- *P. promelas*
- *C. tentans*
- *L. variegatus*
- Other

Measurement Endpoints

- Survival
- Growth
- Reproduction
- Tissue

Weight of Evidence

- Lab tox testing
- Chemistry + SQGs
- Indigenous biota structure/function indices, genetic profiling, fish DELTs, hyporheous)
- Habitat (QHEI)
- Food web modeling
- Retrospective studies

Tier 2: Stressor Class Identification

- Physical stressors (*flow, temperature, suspended solids*)
- Chemical stressor (*PAHs, nonpolars, metals, ammonia*) classes
- *In Situ* testing - *In situ Toxicity Identification Evaluations (TIE)*
- Laboratory testing - *Toxicity Identification Evaluation Phase 1*

Tier 3: Stressor & Source Confirmation

Sediment Lab Assays

- Bioaccumulation (28 day) using *Lumbriculus variegatus* (USEPA)
- Acute (10 day) survival and growth methods for *Hyalella azteca* and *Chironomus tentans*. Whole sediment exposures 2 to 7 d for *Daphnia*, *Ceriodaphnia*, *Pimephales*, *Hydra*, *Hexagenia*.

In Situ Chambers

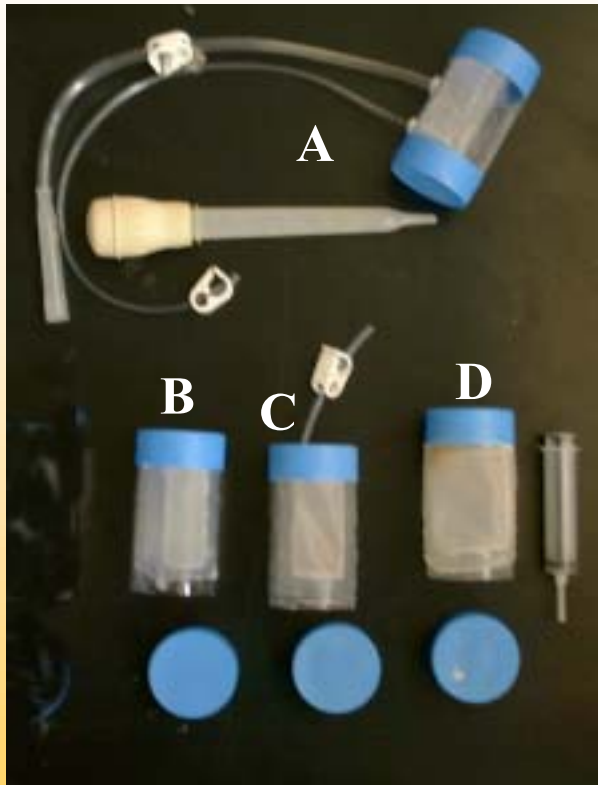


Figure 1

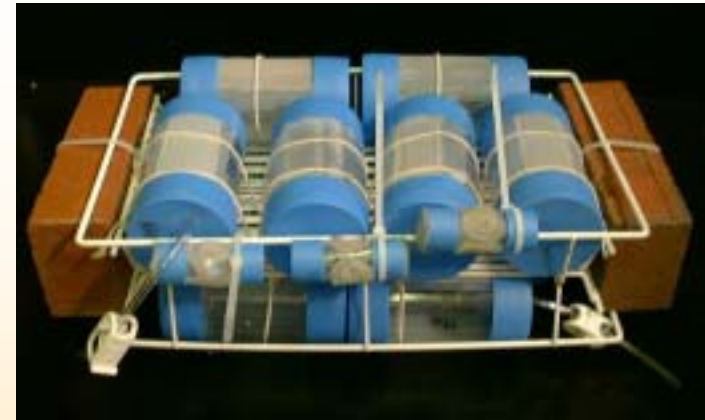


Figure 2

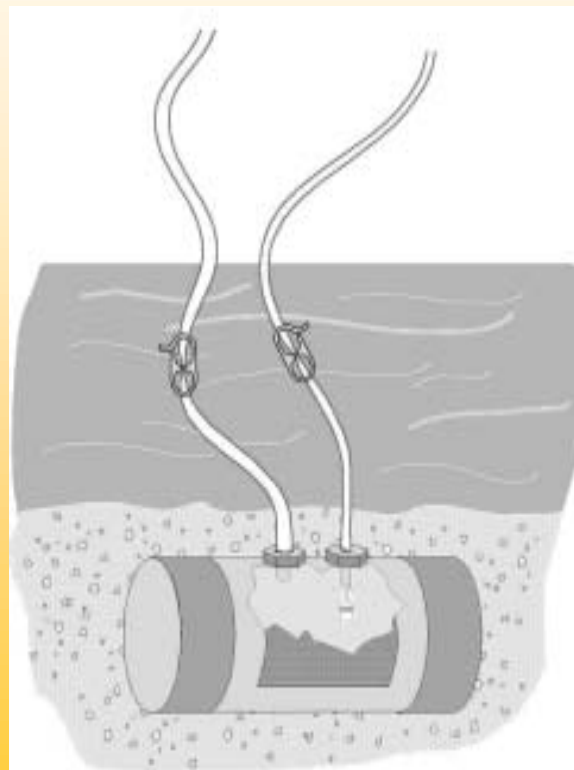
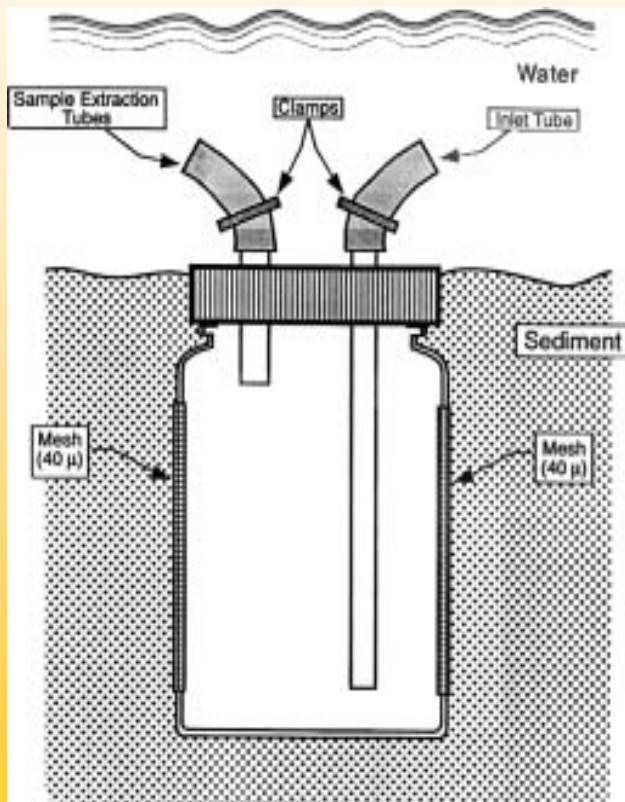


Figure 3



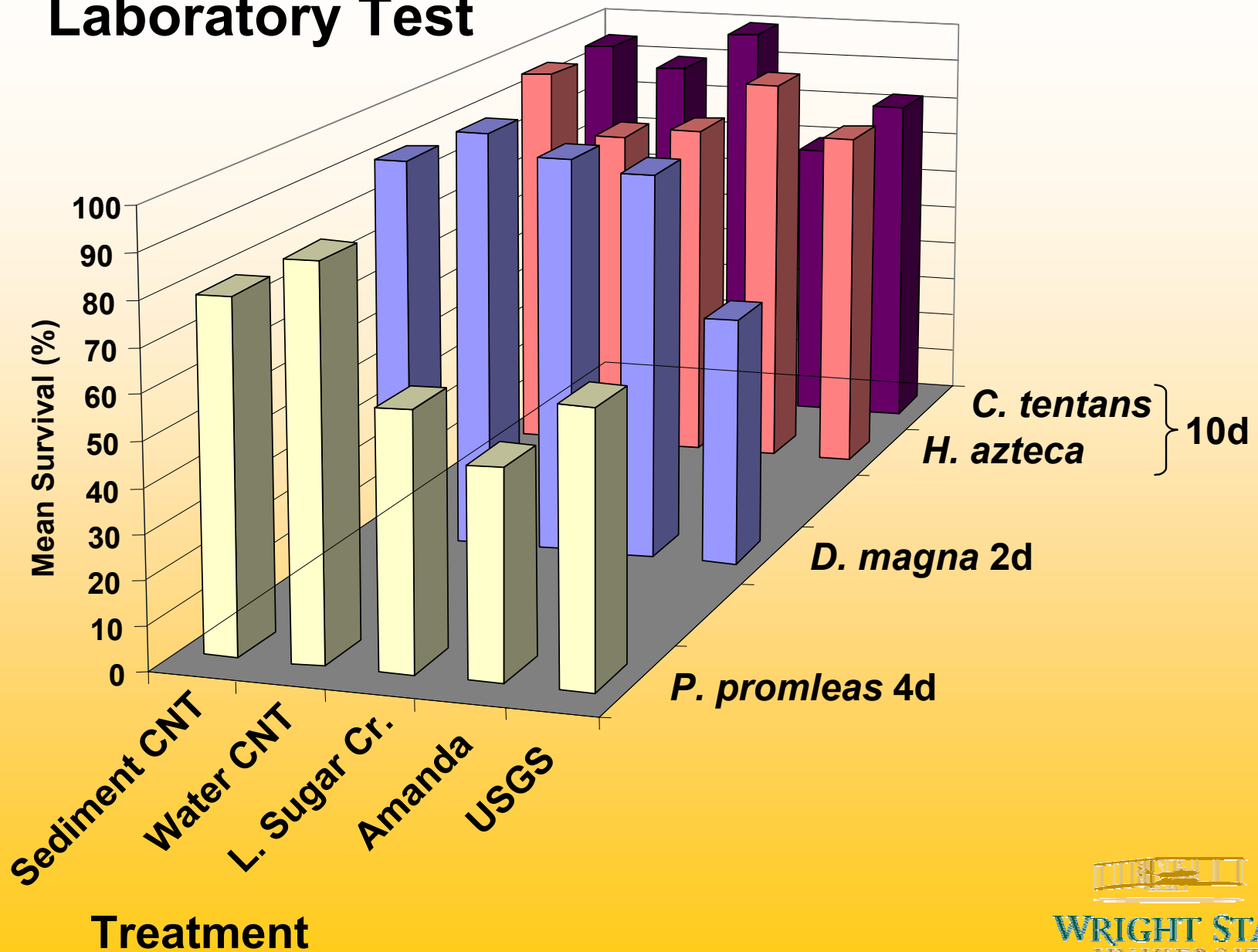
***In situ* Chambers: water & surficial sediment exposures with flow deflectors**

Peepers: Pore water chambers for chemical and toxicity testing

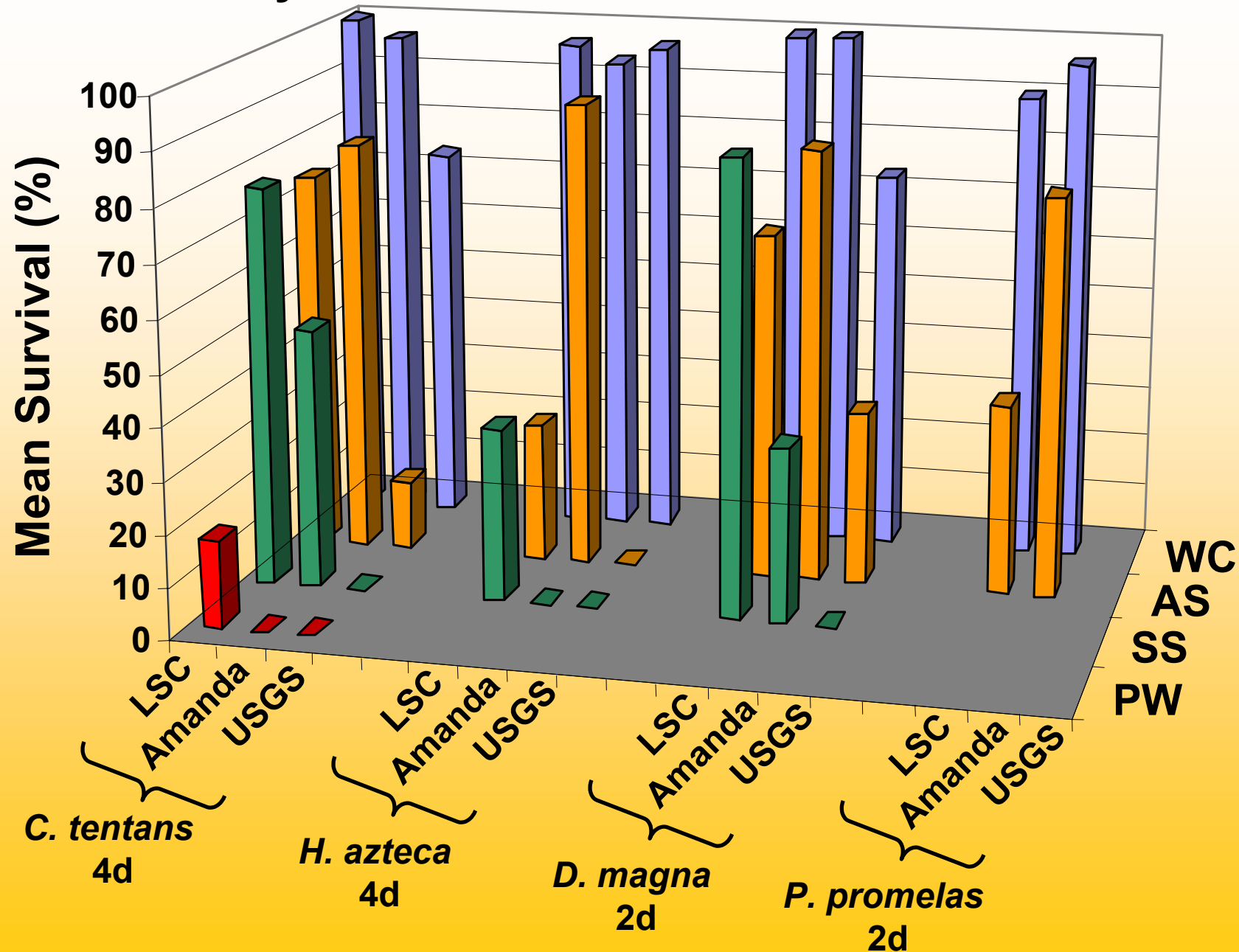


- Initially filled with culture water
- Inserted into sediments
- Equilibration ~ 2 days

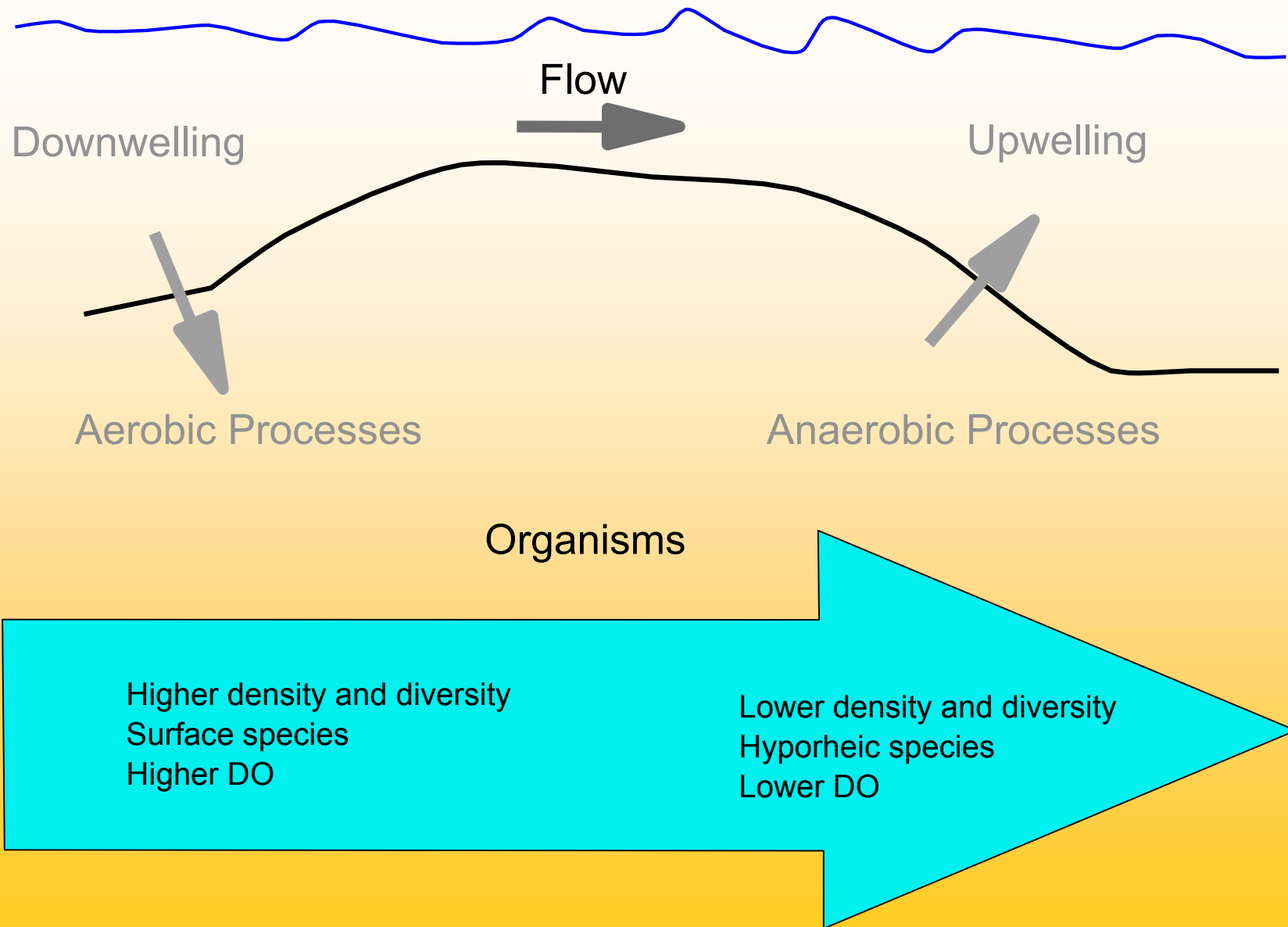
Laboratory Test



In Situ Toxicity Test



How do organisms relate to hydrology?

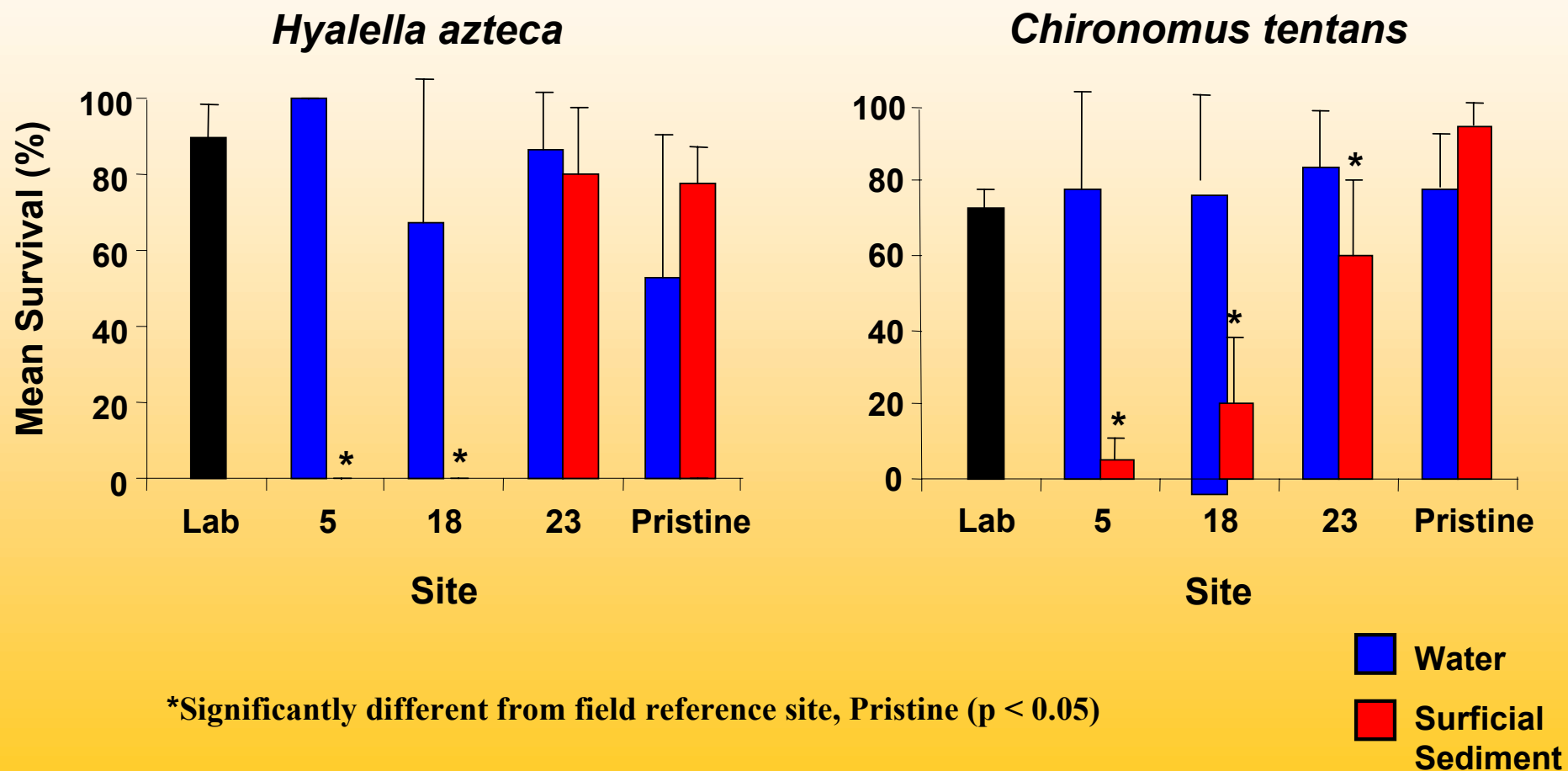


Based on: REAC Report; July 1998

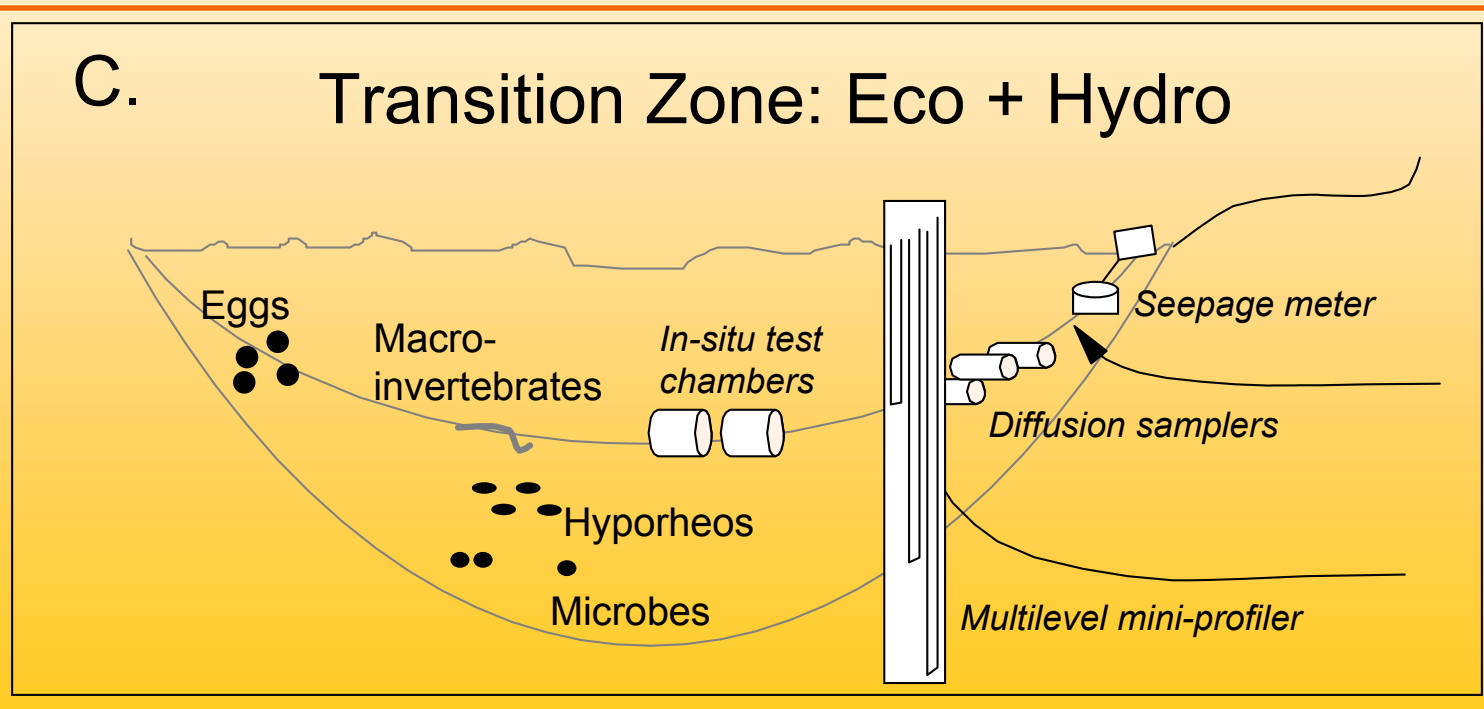
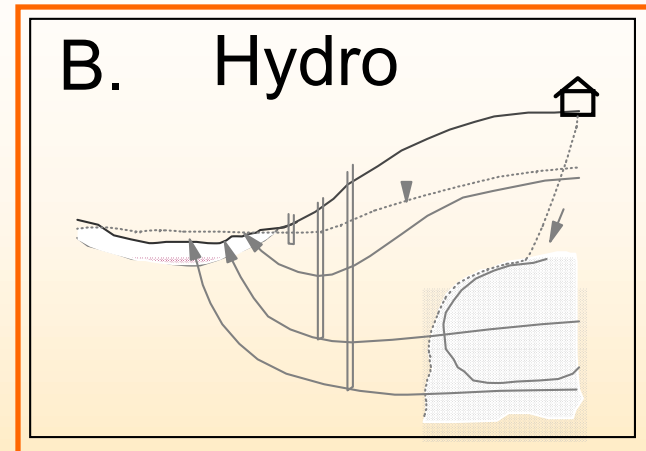
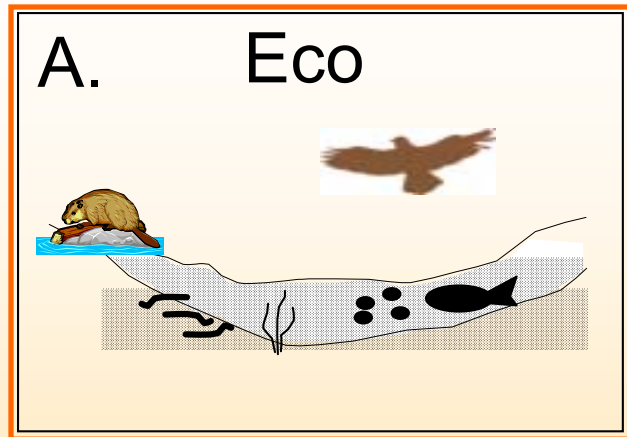
Mini-Piezometer Installation & Reading

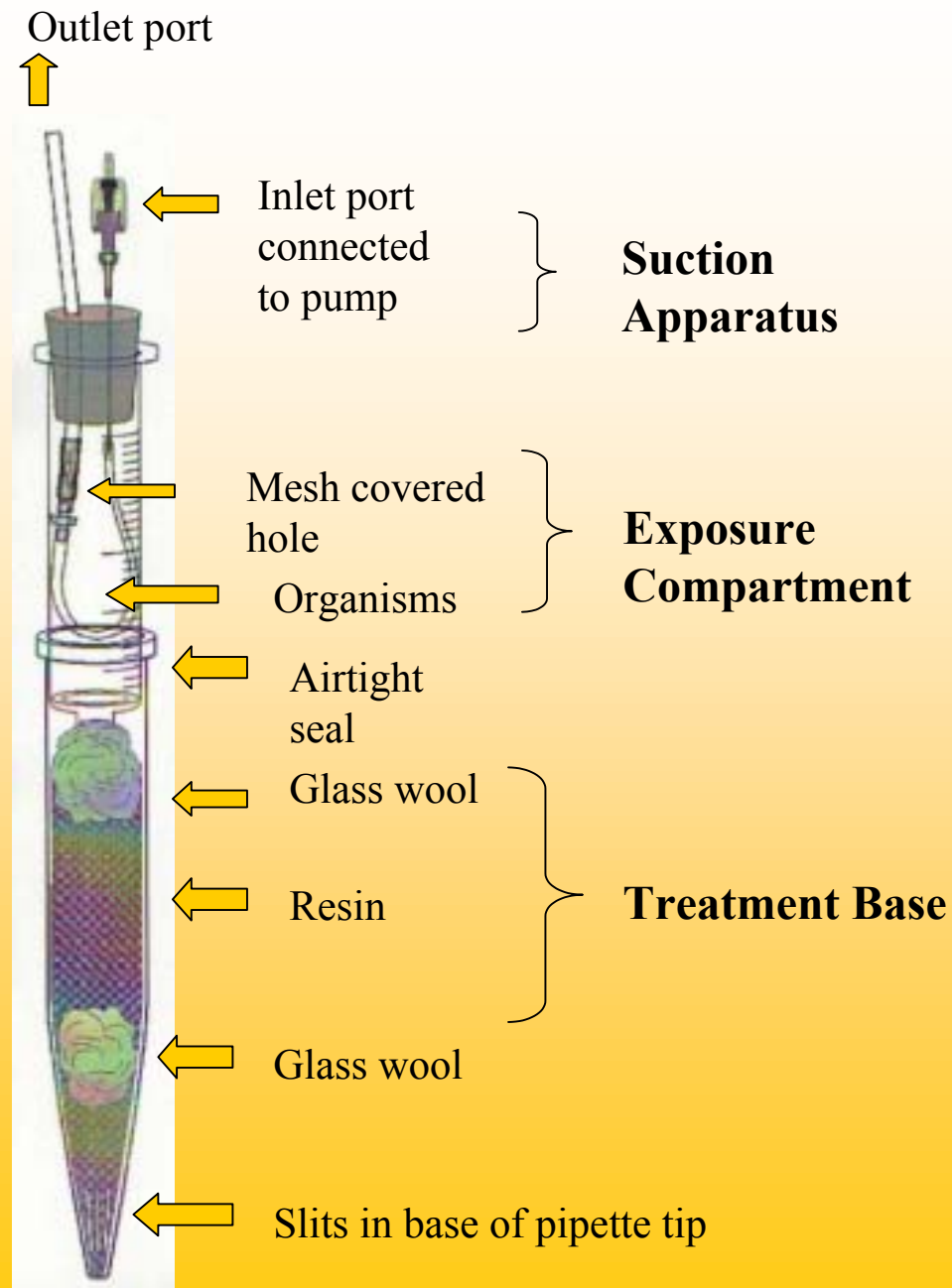


96-h Low Flow *In Situ* Exposure Maine Chlorobenzene Study

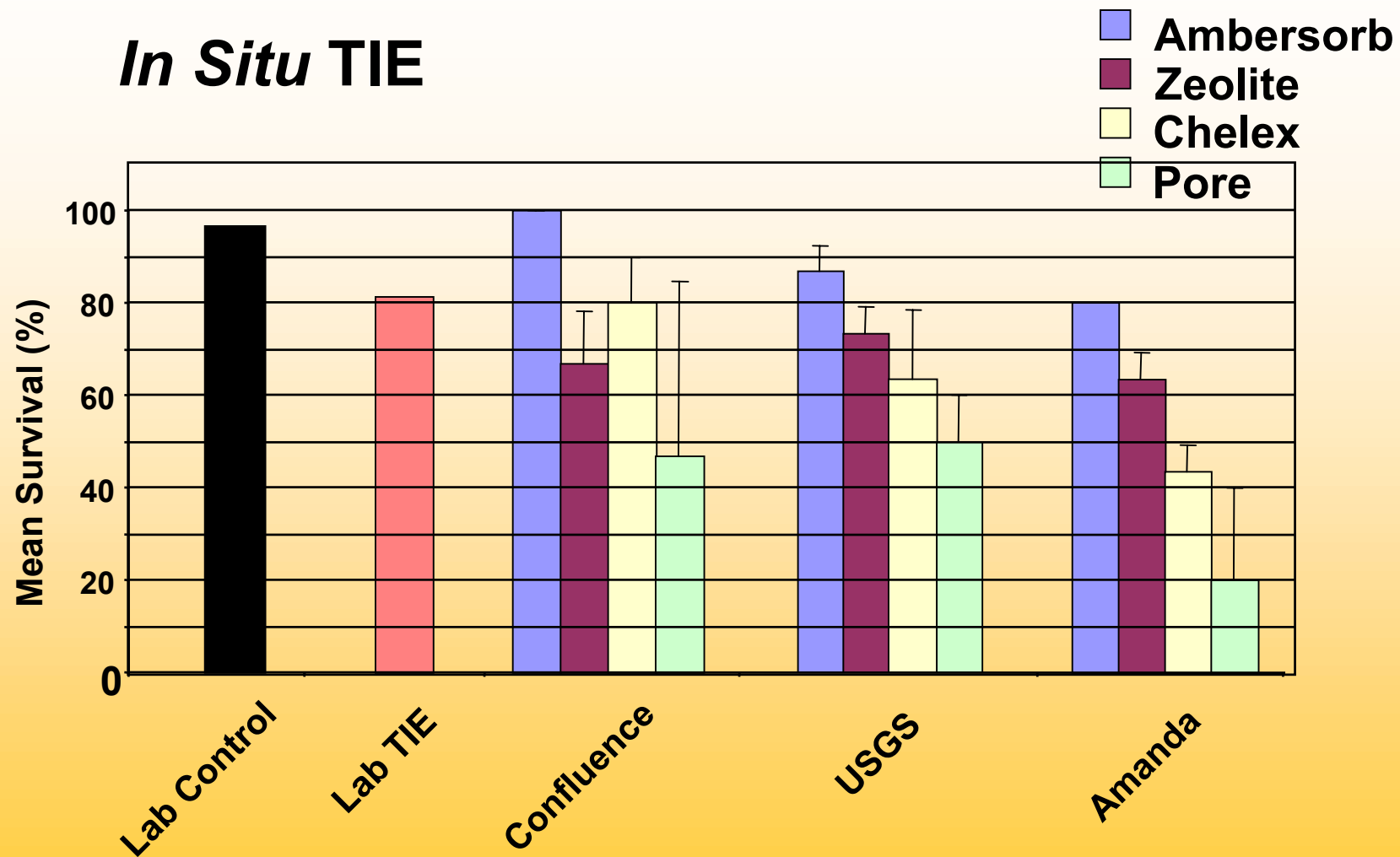


INTEGRATIVE CONCEPTUAL MODEL





In Situ TIE



D. magna survival (\pm SD) following an *in situ* TIE exposure

Strengths/Limitations of Non-Traditional Assessment Methods

- Habitat: essential to life, dominant stressor
- GW/SW Flow: documents exposure, compartmentalize stress
- *In situ* Toxicity and Uptake: improved exposure, compartmentalize stress, minimize artifacts
- *In situ* TIE: improved exposure, minimize artifacts, sensitive
- Habitat: receptor specific, quantification
- GW/SW Flow: logistics
- *In situ* Toxicity and Uptake: logistics, reference site, acclimation, proper deployment
- *In situ* TIE: logistics, proper deployment, screening only

Essential Elements of an Accurate Risk Assessment

Document exposure vs. effects: time & space

(Low flow, high flow, GW/SW interactions, sediment)

Measure toxicity and uptake (2+ species, caged compartments)

Characterize & rank major stressor classes

Nonpolar, Ionizable organics, metals, phototoxicity, suspended solids, flow, habitat, nutrients. Compare to control treatments, reference sites and benchmarks.

Conduct biosurvey of most exposed populations

Benthic community: structure/function measures (define total stress exposure & role of habitat via survey, colonizations, and transplants)

Conclusions

- Tier 1, *In situ*-based conclusions often differ from traditional method conclusions
- Traditional methods predictive of harm, *sometimes...*
- *In situ*-based toxicity and bioaccumulation responses *are more accurate* than lab-based exposures, when properly used.